

ABSTRACT

In the past few decades, the applications of stainless steel materials have increased enormously in various engineering fields. Duplex stainless steel (DSS) combines the benefits of both ferritic stainless steel (FSS) and austenitic stainless steel (ASS) by proper balancing of ferrite and austenite. The duplex structure improves stress-corrosion cracking resistance when compared to ASS. It improves the toughness and ductility when compared to FSS. DSS and super ASS have almost similar properties, which is achieved with overall lower alloy content in DSS. This makes the DSS cost effective for many applications. DSS are extensively being used in many industrial sectors like desalination, chemical tankers, pressure vessels, storage tanks, machinery in the pulp and paper industry, and also in civil engineering applications.

Stainless steels are difficult to machine material due to its high toughness, low thermal conductivity, high degree of work hardening rate and tendency to the built up edge formation. DSS castings like valves, tubes and containers are being produced using conventional induction furnace. The casting products require further machining operations such as turning, drilling, milling etc. Currently the manufacturing industries are facing difficulties in machining of DSS components. The present research work

provides a solution to overcome the present limitations with machining of DSS.

In the present work, two different grades of cast nitrogen alloyed DSS ASTM A 995 grade 5A and 4A are produced using conventional induction furnace in required shapes and sizes. The machining studies are carried out in the above stated specimens in turning and milling operations under dry and wet cutting conditions. The optimum cutting parameters to minimize the surface roughness, cutting force and tool wear during the turning and milling operations are found out by using Taguchi method.

The turning tests are carried out in a medium duty Kirloskar Turn master-35 Lathe using multi coated carbide cutting tool inserts. The experiments are conducted at three different cutting speeds with three different feed rates and a constant depth of cut.

The milling investigations are carried out in a HMT make semi automatic milling machine. The milling operations are performed with a 20 mm diameter end mill cutter with coated carbide inserts. The end milling tests are conducted at three different spindle speeds and three different feed rates with constant depth of cut.

A cutting speed of 100 m/min and a feed rate of 0.04 mm/rev are found to give the lowest surface roughness for 5A and 4A grade DSS during dry and wet turning operations. A cutting speed of 120 m/min and a feed rate of 0.04 mm/rev are found to give the lowest cutting force for 5A and 4A

grade DSS. A cutting speed of 80 m/min and a feed rate of 0.04 mm/rev are found to give the lowest tool wear for both 5A and 4A grade DSS.

A spindle speed of 1000 rpm and a feed rate of 63 mm/min are found to give the lowest surface roughness and cutting force for 5A and 4A grade DSS during dry and wet milling operations. A spindle speed of 500 rpm and a feed rate of 63 mm/min are found to give the lowest tool wear for 5A and 4A grade DSS.

The feed rate is the more significant cutting parameter influencing the surface roughness and cutting force followed by cutting speed for turning and milling operations. The cutting speed is identified as the more significant parameter influencing the tool wear followed by feed rate.

The surface roughness, cutting force and tool wear values for 4A grade DSS are lower compared to 5A grade DSS due to the difference in chemical compositions, which leads to the difference in the formation of micro grains. The presence of higher austenite in 5A grade DSS is the basic reason for the blend of higher hardness and strength as compared to 4A grade DSS. Hence higher cutting forces are required for shearing of the 5A grade DSS, which leads to higher values of surface roughness and tool wear in 5A grade DSS as compared to 4A grade DSS.

The application of cutting fluid reduces chip friction during wet machining. Lower friction at the tool-chip interface leads to lower cutting temperature which results in less tool wear, less cutting force and better

surface finish. The surface roughness, the cutting force and tool wear values of wet machining operations are reduced by about 5-30 % compared to the dry machining operations.

Box-Behnken design response surface methodology is used to develop a second order quadratic model to predict surface roughness in terms of spindle speed, feed rate and axial depth of cut during milling operation. The predicted results are compared with experimental results and the error is within 5%.